



Thermal Analysis Using Assembly FEMs in Teamcenter, NX and Space Systems Thermal

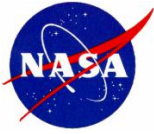
by

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Jet Propulsion Laboratory,
California Institute of Technology

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Thermal Analysis within Teamcenter



-
- You can work within Teamcenter to perform an orbital thermal analysis of a spacecraft.
 - Use existing NX parts and assemblies.
 - Create FEMs and Sims directly off of the parts in Teamcenter.
 - Create assembly FEMs to match the assembly parts.
 - Map part FEMs onto the assembly FEMs.
 - Import thermal couplings and loads from the lower level Sims.
 - Define and display orbits.
 - Solve in Space Systems Thermal.



Start with Teamcenter



My Teamcenter - Teamcenter 8

File Edit View Tools Window Help

My Teamcenter (Krylo, Robert (rkrylo) - EngAnalysis / Thermal [JPL-PRD]

Search

Enter Item ID to search

Quick Links

Home

My Worklist

My Projects

My Links

My Saved Searches

Open Items

Close All

Checked-Out Objects (3)

Checked-Out Objects (2)

Checked-Out Objects (1)

rjk_SWOT_10m_baseline_assysim

Home

History

Favorites

Organize

Home

Search Text

Summary Details Viewer Impact Analysis JT Preview

Object	Type	Relation	Own...	Grou...	Date
Mailbox	Mail Folder	Contents	Kryl...	Inac...	21-M
Newstuff	Newstuff Fo...	Contents	Kryl...	Inac...	16-D
Library	Folder	Contents	info...	dba	30-A
Markup folder	Folder	Contents	Kryl...	Eng...	05-M
SWOT	Folder	Contents	Kryl...	Eng...	27-J
Jason-3	Folder	Contents	Kryl...	Eng...	30-A
Test materials-suffix	Item	Contents	Kryl...	Eng...	28-S
My Saved Searches	Folder	Contents	Kryl...	Eng...	13-A

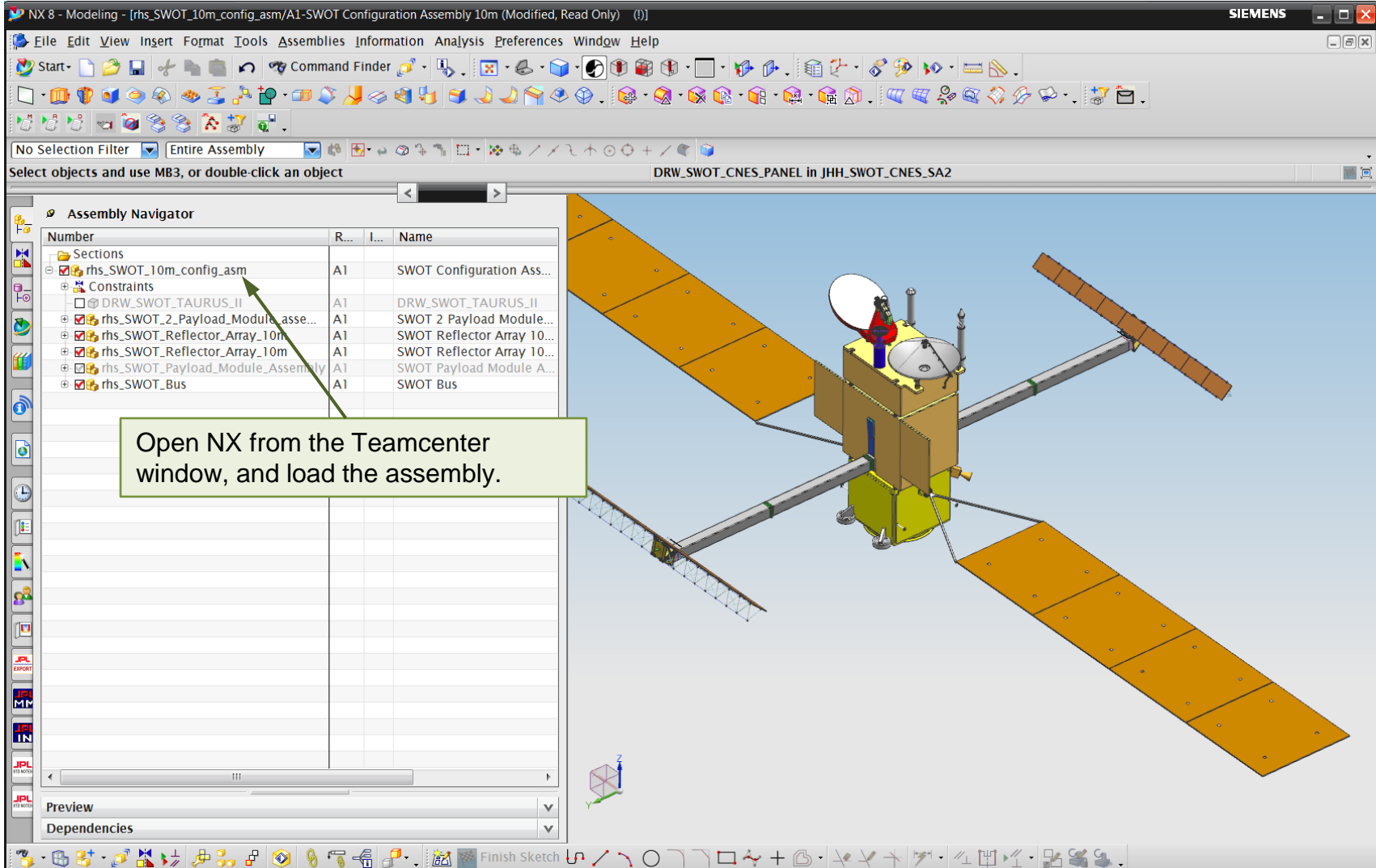
Start with a spacecraft, available as an NX assembly in Teamcenter. You can build your thermal model directly on the NX parts so the model will be associative, modular, accessible to other thermal engineers, and under the configuration control of Teamcenter.

To begin:
Open Teamcenter and create a directory for your files.

Search Results



Open NX and the Assembly





Select a Part



The screenshot shows the SolidWorks software interface. The top menu bar includes File, Edit, View, Insert, Format, Tools, Assemblies, Information, Analysis, Preferences, Window, and Help. Below the menu is a toolbar with various icons for file operations, editing, and assembly management. The main window displays a 3D model of a satellite with orange solar panels and a central body. On the left, the Assembly Navigator is open, showing a tree structure of the assembly. A table within the navigator lists parts and their relationships.

Number	R...	I...	Name
Sections			
rhs_SWOT_10m_config_asm	A1		SWOT Configuration Ass
Constraints			
DRW_SWOT_TAURUS_II	A1		DRW_SWOT_TAURUS_II
rhs_SWOT_2_Payload_Module_ase...	A1		SWOT 2 Payload Module
Constraints			
rhs_SWOT_Dual_Module_Heat_Pip...	A1		rhs_SWOT_Dual_Module.
rhs_X-Band_Antenna	A1		rhs_X-Band_Antenna
rhs_X-Band_Antenna_Base	A1		rhs_X-Band_Antenna_Bas
rhs_SWOT_2_Upper_Module_Ase...	A1		rhs_SWOT_2_Upper_Mod
rhs_SWOT_2_Lower_Module_Ase...	A1		rhs_SWOT_2_Lower_Mod
Constraints			
rhs_SWOT_Dual_Module_Heat...	A1		rhs_SWOT_Dual_Module.
rhs_ADC	A1		rhs_ADC
rhs_swot_LHP_evap_short	A1		rhs_swot_LHP_evap_shor
rhs_SWOT_HVPS_Pallet	A1		rhs_SWOT_HVPS_Pallet
rhs_SWOT_Panel-Y_1.425m	A1		SWOT Panel-Y 1.425m
rhs_SWOT_Panel-X_Bottom	A1		rhs_SWOT_Panel-X_Botto
rhs_SWOT_Panel-Z_1.425m	A1		SWOT Panel-Z 1.425m
rhs_SWOT_Thermal_Panel_+Y_1...	A1		SWOT Thermal Panel +Y
rhs_SWOT_Thermal_Panel_+Y_1...	A1		SWOT Thermal Panel +Y
rhs_swot_metering_structure	A1		rhs_swot_metering_stru
rhs_SWOT_Flexure_Brkt	A1		rhs_SWOT_Flexure_Brkt
rhs_SWOT_Flexure_Brkt	A1		rhs_SWOT_Flexure_Brkt
rhs_SWOT_Flexure_Brkt	A1		rhs_SWOT_Flexure_Brkt
rhs_SWOT_Flexure_Brkt	A1		rhs_SWOT_Flexure_Brkt
rhs_SWOT_Metering_Strut	A1		rhs_SWOT_Metering_Stru
rhs_SWOT_Metering_Strut	A1		rhs_SWOT_Metering_Stru
rhs_SWOT_Metering_Strut	A1		rhs_SWOT_Metering_Stru
rhs_SWOT_Metering_Strut	A1		rhs_SWOT_Metering_Stru
rhs_SWOT_PM_Fitting	A1		SWOT Payload Module F
rhs_SWOT_PM_Fitting	A1		SWOT Payload Module F

A green callout box with a green arrow pointing to the highlighted part in the table contains the text: "Pick a part for analysis. Then right-click and make it the displayed part."



Create a FEM and SIM



NX 8 - Advanced Simulation - [rhs_SWOT_Thermal_Panel_Y 1.425m/A1-SWOT Thermal Panel +Y 1.425m (Read Only) (I)]

File Edit View Insert Format Tools Assemblies Information Analysis Preferences Window Help

Start Command Finder

No Selection Filter Entire Assembly

Simulation Navigator

Object	Status	Env
rhs_SWOT_Thermal_Panel_Y 1.425m/A1		

- New FEM...
- New FEM and Simulation...
- New Assembly FEM...

Simulation File View

Session

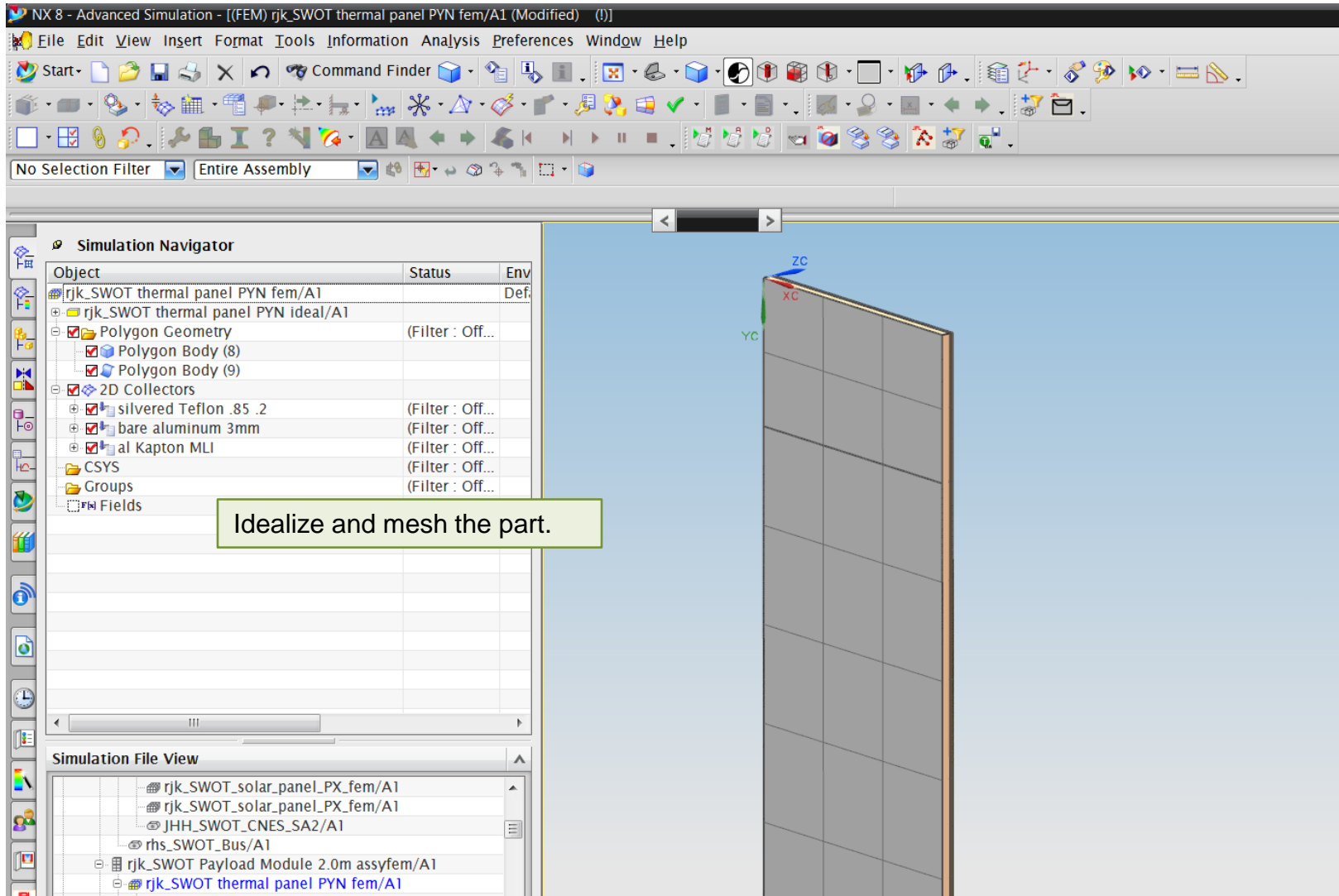
- rjk_SWOT_10m_baseline_assysim/A1
 - rjk_SWOT_10m_config_assyfem/A1
 - rjk_SWOT Refl Array 10m NY assyfem/A1
 - rjk_SWOT RA 10m Boom Inner NY fem/A1
 - rhs_SWOT_Reflector_Array_10m/A1

Switch to Advanced Simulation and go to the Simulation Navigator. Then create a new FEM and Sim. For an orbital thermal model, choose NX Space Systems Thermal as the solver.

Tip: Be careful with your file names. You will have an easier time finding things if you start with the part name and add the CAE terms "ideal", "fem", "assyfem", "sim", or "assysim". Using the existing part name helps later when you map part FEMs to assembly FEMs. CAE terms in the name help in the Simulation File View where you won't see file extensions. Also note that names in Teamcenter cannot be re-used.

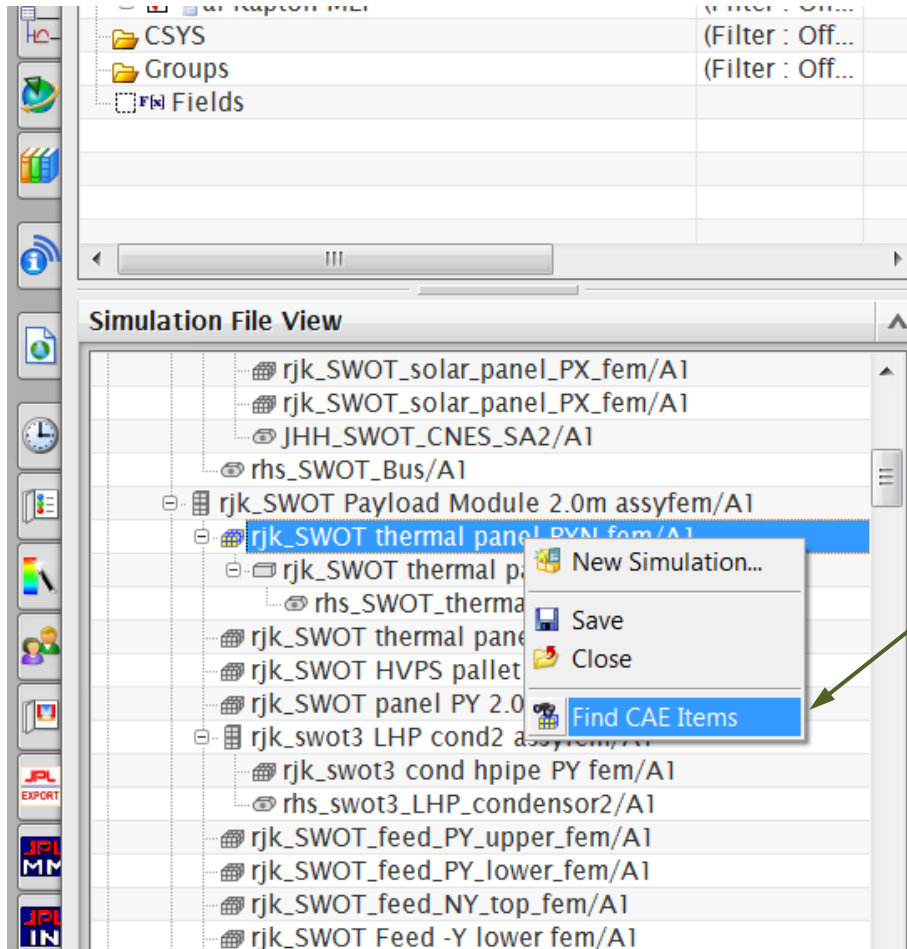


Idealize and Mesh





Open the Sim



Switch to the Sim.
Tip: If you already have a Sim, you can quickly open it by going to the Simulation file View, right-clicking the FEM, and clicking Find CAE Items. This switches you to the Search Results mode where you can double-click the Sim. You can switch back to the Session View with a right-click on the Search Results.



Add Simulation Objects



NX 8 - Advanced Simulation - [(Simulation) rjk_SWOT thermal panel PYN sim/A1 (Modified) (!)]

File Edit View Insert Format Tools Information Analysis Preferences Window Help

Start Command Finder

No Selection Filter Entire Assembly

Simulation Navigator

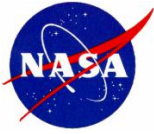
Object	Status	Env
rjk_SWOT thermal panel PYN sim/A1		Def
rjk_SWOT thermal panel PYN fem/A1		Def
CSYS	(Filter : Off...	
Groups	(Filter : Off...	
DOFSets	(Filter : Off...	
Regions	(Filter : Off...	
Fields		
Simulation Object Container	(Filter : Off...	
honeycomb 180W/m2C	Active	
MLI ester .03	Active	
Load Container	(Filter : Off...	
Constraint Container	(Filter : Off...	
Soln 1	Active	NX
Simulation Objects	(Filter : Off...	
Constraint Set	(Filter : Off...	
Loads	(Filter : Off...	

Simulation Search View

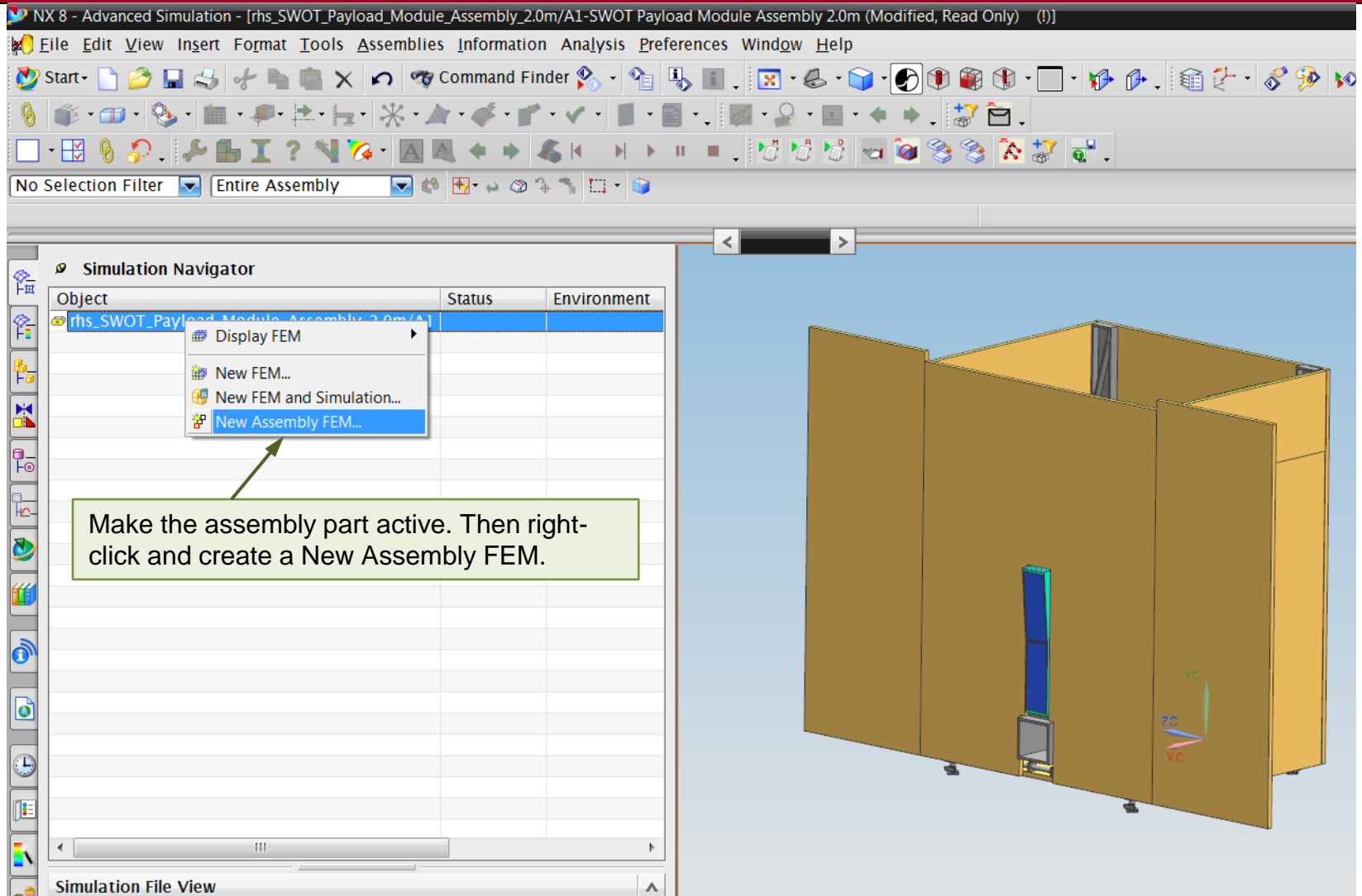
Teamcenter Search Results

- rjk_SWOT thermal panel PYN fem/A1
 - rjk_SWOT thermal panel PYN sim/A1

Add your Simulation Objects such as thermal couplings and heat loads. You will later import these into the higher level Sim.



Create a New Assembly FEM





Map the Part FEM



NX 8 - Advanced Simulation - [(Assembly FEM) rjk_SWOT Payload Module 2.0m assyfer/A1 (Modified) (I)]

File Edit View Insert Format Tools Assemblies Information Analysis Preferences Window Help

Start Command Finder

No Selection Filter Entire Assembly

Simulation Navigator

Object	Status	Environment
rjk_SWOT Payload Module 2.0m assyfer/A1		Default: NX
rhs_SWOT_Payload_Module_Assembly_2.0...		
rhs_SWOT_thermal_panel_+y/A1	Ignored	
rhs_SWOT_thermal_panel_+y/A1		
rhs_SWOT_Comm_Ant/A1		
rhs_SWOT_Poseidon_Bracket_2/A		
DRW_DORIS_ANTENNA_FOV/A1		
DRW_LASER_REFLECTOR_FOV/A		
rhs_SWOT_Panel_Bracket2/A1	Ignored	
rhs_SWOT_Panel_Bracket2/A1	Ignored	
rhs_SWOT_Panel_Bracket1/A1	Ignored	
rhs_SWOT_Panel_Bracket1/A1	Ignored	
rhs_SWOT_Panel_Bracket/A1	Ignored	
rhs_SWOT_Panel_Z2_2.0m/A1	Ignored	
rhs_SWOT_RUAG_x-band_LGA/A1	Ignored	
rhs_SWOT_RUAG_x-band_LGA/A1	Ignored	
rhs_SWOT_Antenna_Bracket_2/A1	Ignored	
rhs_SWOT_Antenna_Bracket/A1	Ignored	
rhs_SWOT_Panel_Bracket/A1	Ignored	
rhs_SWOT_panel_+z2_2.0m/A1	Ignored	
rhs_SWOT_panel+z_2.0m/A1	Ignored	
rhs_SWOT_Payload_Structure_Assembly_...	Ignored	

Map the part FEM onto the assembly FEM by right-clicking on the part and selecting Map Existing.



Map All Part FEMs



Simulation Navigator

Object	Status	Env
rjk_SWOT Payload Module 2.0m assyfer/A1		
rhs_SWOT_Payload_Module_Assembly_2.0...		
rhs_SWOT_thermal_panel_+y/A1	rjk_SWOT t...	
rhs_SWOT_thermal_panel_+y/A1	rjk_SWOT t...	
rhs_SWOT_Comm_Ant/A1	SWOT Co...	
rhs_SWOT_Poseidon_Bracket_2/A1	Ignored	
DRW_DORIS_ANTENNA_FOV/A1	Ignored	
DRW_LASER_REFLECTOR_FOV/A1	Ignored	
rhs_SWOT_Panel_Bracket2/A1	Ignored	
rhs_SWOT_Panel_Bracket2/A1	Ignored	
rhs_SWOT_Panel_Bracket1/A1	Ignored	
rhs_SWOT_Panel_Bracket1/A1	Ignored	
rhs_SWOT_Panel_Bracket1/A1	Ignored	
rhs_SWOT_Panel_Z2_2.0m/A1	rjk_SWOT ...	
rhs_SWOT_RUAG_x-band_LGA/A1	Ignored	
rhs_SWOT_RUAG_x-band_LGA/A1	Ignored	
rhs_SWOT_Antenna_Bracket_2/A1	Ignored	
rhs_SWOT_Antenna_Bracket/A1	Ignored	
rhs_SWOT_Panel_Bracket/A1	Ignored	
rhs_SWOT_panel_+z2_2.0m/A1	rjk_SWOT ...	
rhs_SWOT_panel+z_2.0m/A1	rjk_SWOT ...	
rhs_SWOT_Payload_Structure_Assembly_...	rik_SWOT ...	

Simulation File View

Session

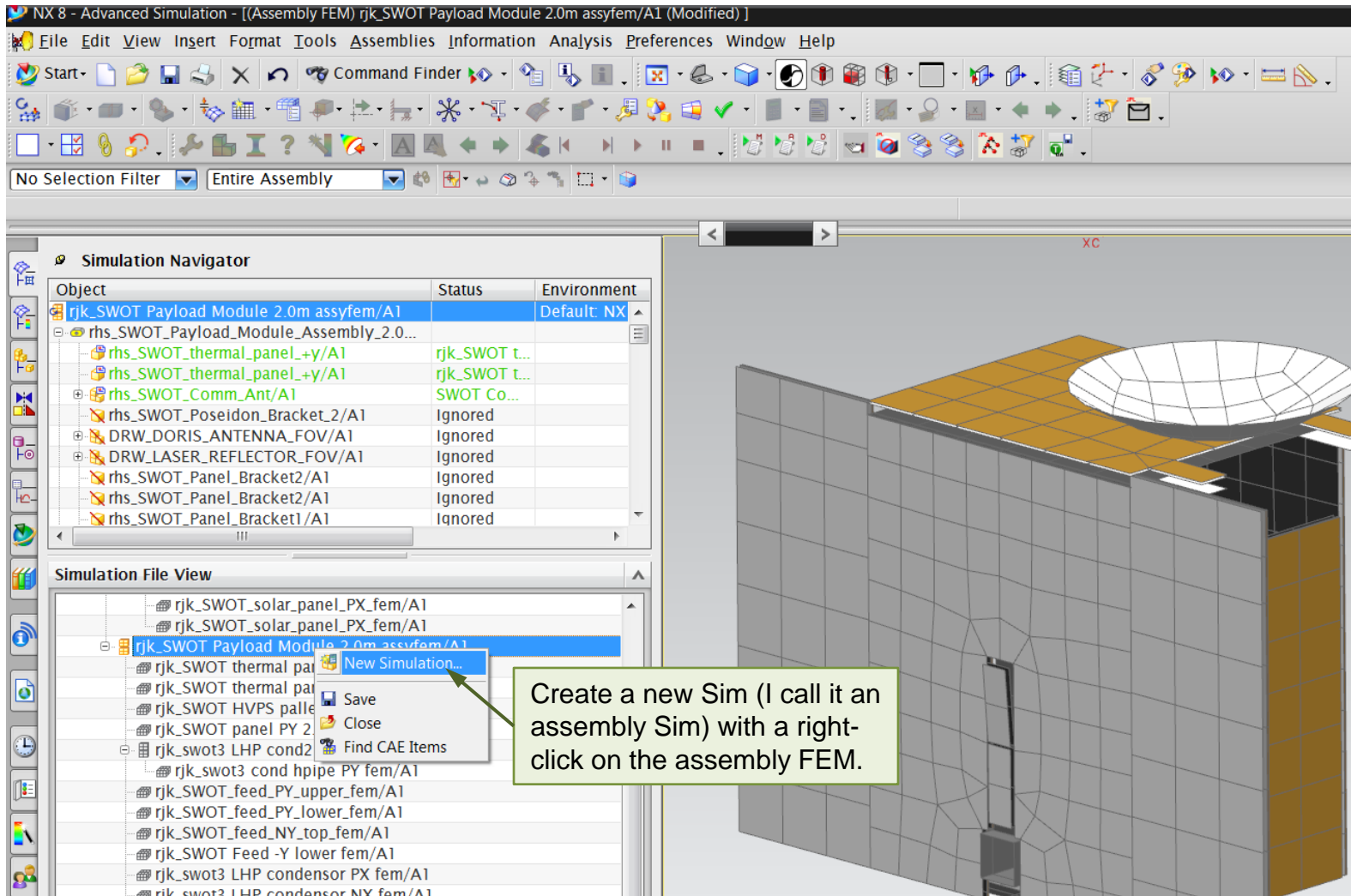
- rjk_SWOT_10m_baseline_assysim/A1
 - rjk_SWOT_10m_config_assysim/A1
 - rjk_SWOT Refl Array 10m NY assyfer/A1
 - rjk_SWOT RA 10m Boom Inner NY fem/A1
 - rhs_SWOT_Reflector_Array_10m/A1

Keep mapping until your assembly FEM is complete. You can replace a part FEM by right-clicking the part, selecting Ignore, and mapping another FEM to the part.

Tip:
Right-click the FEM, go to the Label Manager, and resolve the label conflicts. The orbit plotter and thermal couplings will not work with label conflicts.



Create an Assembly Sim





Import Simulation Entities



The screenshot displays the 'Simulation Navigator' window on the left, which lists simulation objects and their environments. The 'Object' column lists various components like 'rjk_SWOT Payload Module 2.0m assysim/A1', 'rjk_SWOT Payload Module 2.0m assyfem...', and 'rhs_SWOT_Payload_Module_Assembly_2....'. The 'Status' column shows 'Update Pe...' for the first two. The 'Environment' column lists 'Default: NX' for most items. A context menu is open over the 'rjk_SWOT thermal panel PYP fem/A1' entry, with the 'Import Simulation Entities' option highlighted. A green callout box with an arrow pointing to this option contains the text: 'Import the thermal couplings from the part Sims by right-clicking the part FEM and choosing Import Simulation Entities.' The main 3D view on the right shows a detailed model of a satellite structure with a large dish antenna and various panels, with a coordinate system 'XC' visible in the top right corner.

Object	Status	Environment
rjk_SWOT Payload Module 2.0m assysim/A1		Default: NX
[-] rjk_SWOT Payload Module 2.0m assyfem...	Update Pe...	Default: NX
[-] rhs_SWOT_Payload_Module_Assembly_2....		
[-] SWOT Comm Ant assyfem/A1		Default: NX
[-] SWOT Panel +Z fem/A1		Default: NX
[-] rjk_SWOT panel -Z fem/A1		Default: NX
[-] rjk_SWOT_panel -Y 2.0m fem/A1		Default: NX
[-] rjk_SWOT Payload Structure assyfem/A1		Default: NX
[-] rjk_SWOT panel PX 2 2m fem/A1		Default: NX
[-] rjk_SWOT panel NX 1 2m fem/A1		Default: NX
[-] rjk_SWOT panel PX 1 2m fem/A1		Default: NX
[-] rjk_SWOT panel NX 2 2m fem/A1		Default: NX
[-] rjk_swot3 pallet NX fem/A1		Default: NX
[-] rjk_swot3 pallet PX fem/A1		Default: NX
[-] rjk_swot3 LHP condensor PY fem/A1		Default: NX
[-] rjk_swot3 LHP condensor NX fem/A1		Default: NX
[-] rjk_swot3 LHP condensor PX fem/A1		Default: NX
[-] rjk_SWOT Feed -Y lower fem/A1		Default: NX
[-] rjk_SWOT_feed_NY_top_fem/A1		Default: NX
[-] rjk_SWOT_feed_PY_lower_fem/A1		Default: NX
[-] rjk_SWOT_feed_PY_upper_fem/A1		Default: NX
[-] rjk_swot3 LHP cond2 assyfem/A1		Default: NX
[-] rjk_SWOT panel PY 2.0m fem/A1		Default: NX
[-] rjk_SWOT HVPS pallet fem/A1		Default: NX
[-] rjk_SWOT thermal panel PYP fem/A1		Default: NX
[-] rjk_SWOT thermal panel PVAL fem/A1		Default: NX
CSYS		
Groups		
DOESatc		

Simulation Search View

Teamcenter Search Results

- [-] rjk_SWOT Payload Module 2.0m assyfem/A1
- [-] rjk_SWOT Payload Module 2.0m assysim/A1



Choose Names and Entities



The screenshot shows the SolidWorks software interface. On the left, the **Simulation Navigator** panel lists various simulation objects. A green callout box points to the list with the following text:

Browse to the Sim that corresponds to the FEM. Prepend any descriptive text you want (the default part name is usually too long). Choose which entities to import.

On the right, the **Import Simulation Entities** dialog box is open. It has two main sections:

- Source Simulation:** Contains a **File Browser** field with the text "rjk_SWOT thermal panel PYN si" and a **String to prepend simulation entity names** field with the text "thermal panel PYN".
- Import Entities:** A list of checkboxes for selecting entities to import. All checkboxes are checked:
 - ☒ Loads
 - ☒ Constraints
 - ☒ Simulation Objects
 - ☒ Materials
 - ☒ Fields
 - ☒ Modeling Objects
 - ☒ Physical Property Tables
 - ☒ Groups
 - ☒ Regions
 - ☒ Solutions
 - ☒ DOF Sets

At the bottom of the dialog are buttons for **All On**, **All Off**, **OK**, **Apply**, and **Cancel**.



Map Remaining Assembly and Part FEMs

NX 8 - Advanced Simulation - [(Assembly FEM) rjk_SWOT_10m_config_assyfem/A1 (Modified) (I)]

File Edit View Insert Format Tools Assemblies Information Analysis Preferences Window Help

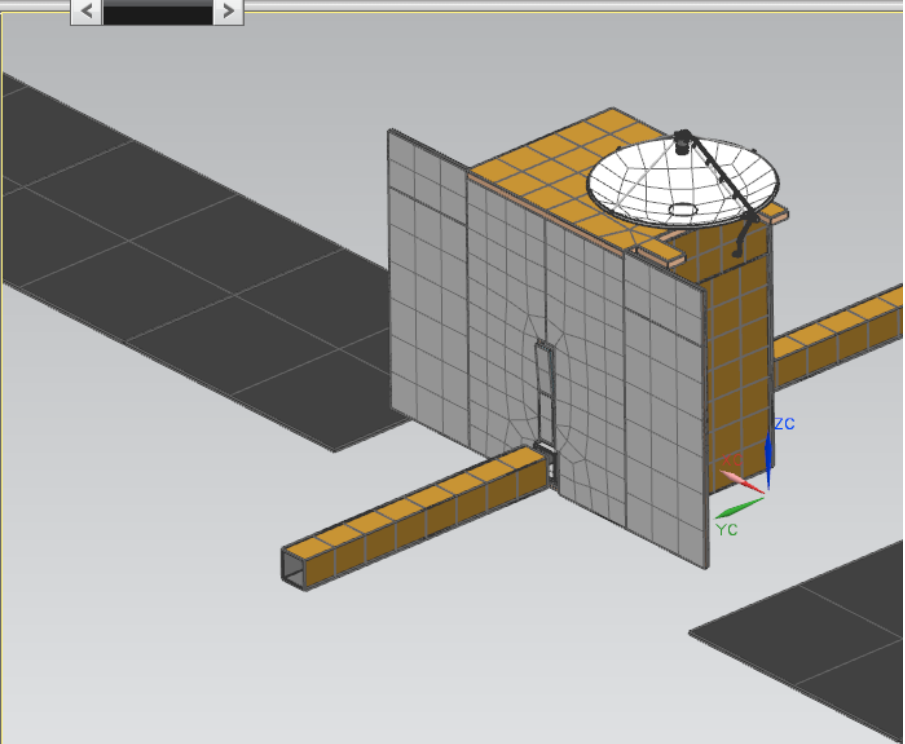
Start Command Finder

No Selection Filter Entire Assembly

Simulation Navigator

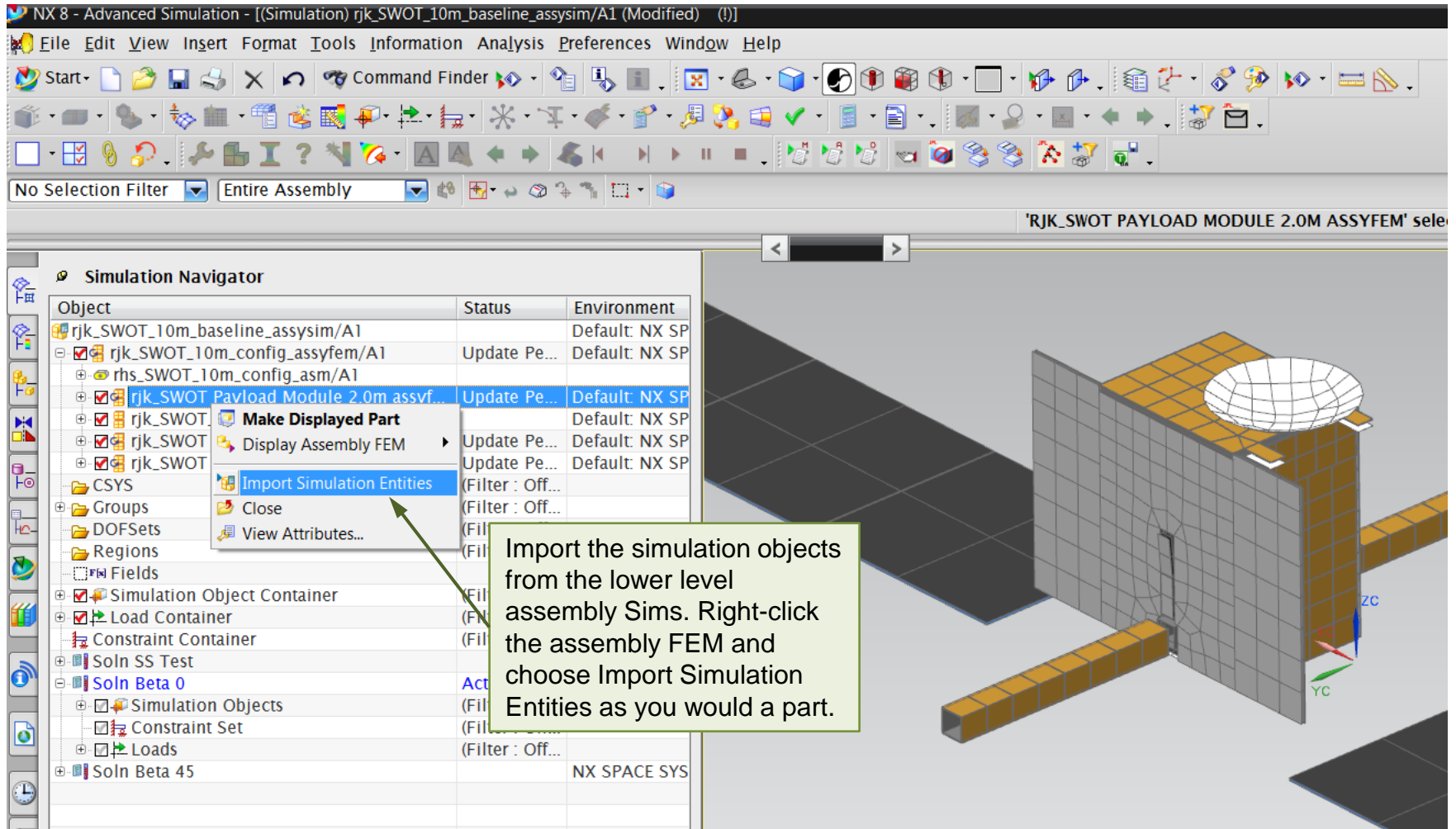
Object	Status	Environment
rjk_SWOT_10m_config_assyfem/A1		Default: NX SP
rhs_SWOT_10m_config_asm/A1		
✓ rjk_SWOT Payload Module 2.0m assyfem...	Update Pe...	Default: NX SP
✓ rjk_SWOT_Bus_assyfem/A1		Default: NX SP
✓ rjk_SWOT Refl Array 10m +Y assyfem/A1	Update Pe...	Default: NX SP
✓ rjk_SWOT Refl Array 10m NY assyfem/A1	Update Pe...	Default: NX SP
CSYS	(Filter : Off...	
Groups	(Filter : Off...	
Fields		

Work your way up to the top-level assembly FEM by mapping lower level assembly FEMs. You can map any combination of part FEMs and assembly FEMs.





Import Entities from Sub-Assemblies





Prepare External Radiation



Simulation Navigator

Object	Status	Environment
rjk_SWOT_10m_config_assyfem/A1	Update Pe...	Default: NX
rhs_SWOT_10m_config_asm/A1		
rjk_SWOT Payload Module 2.0m assyf...	Update Pe...	Default: NX
rjk_SWOT_Bus_assyfem/A1		Default: NX
rjk_SWOT Refl Array 10m +Y assyfem/...	Update Pe...	Default: NX
rjk_SWOT Refl Array 10m NY assyfem/...	Update Pe...	Default: NX
CSYS	(Filter : Off...	
Groups	(Filter : Off...	
1 - External radiation top		
2 - External radiation bottom		
3 - Elements for plotting		
4 - Surfaces for orbital plotting		
5 - All elements		
6 - Baseline elements		
DOFSets		
Regions		
Fields		
Simulation Object Container		
Orbital Heating Beta 0	Active	
External radiation	Active	
Bus_SA_NX_solar_array_Honeycomb 1...	Active	
Bus_SA_NX_solar_array_Honeycomb 1...	Active	
Bus_SA_NX_solar_array_Honeycomb 1...	Active	
Bus_SA_NX_solar_array_Honeycomb 1...	Active	

Simulation File View

Session

- rjk_SWOT Payload Module 2.0m assysim/A1
- rjk_SWOT Payload Module 2.0m assyfem/A1

External radiation

Name

Top Side Region

☒ Group Reference External radiation top

Filter Type Polygon Face

☒ Select Object (40)

Excluded

Bottom Side Region

☒ Group Reference External radiation bottom

Filter Type Polygon Face

☒ Select Object (2)

Element Selection Filtering

Excluded

Parameters

☒ Include Radiative Environment

Calculation Method Hemicube Rendering

View Factor Accuracy Medium (128 x 128)

Element Subdivision 3

☐ Elements not Part of this Enclosure Can Shadow

Card Name Enclosure Radiation

OK Apply Cancel

Create groups of external radiation surfaces to use for both radiation and orbital heating.



Prepare Orbital Heating



No Selection Filter | Entire Assembly | No method

Select region illuminated on top side

Orbital Heating Beta 45

Simulation Navigator

- Object
 - RA_RA 10m
 - RA_RA 10m
 - Beta 0 by s
 - Orbital Hea
 - solar array
 - Orbital Hea
 - Orbital Hea
 - PM_Panel +
 - PM_Panel +
 - PM_panel -2
 - PM_panel -Y
 - PM_panel -Y
 - PM_CCHP P
 - PM_CCHP P
 - PM_CCHP N
 - PM_CCHP P
 - PM_Feed -Y
 - PM_feed_NY
 - PM_feed_PY
 - PM_feed_PY
 - PM_Feeds t
 - PM_Feeds t
 - PM_Feeds t

Simulation File View

- Session
 - rjk_SWOT Paylo
 - rjk_SWOT Pa
 - rjk_SWOT
 - rjk_SWOT
 - rjk_SWOT
 - rjk_SWOT
 - rjk_swot3
 - rjk_swo
 - rhs_swo
 - rjk_SWOT_feed_PY_upper_fem/A1
 - rik SWOT feed PY lower fem/A1

Orbital Heating Beta 45 Properties

Name: Orbital Heating Beta 45

Label:

Description:

Top Side Illuminated Region

- ☒ Group Reference: External radiation top
- Filter Type: Polygon Face
- ☒ Select Object (40)
- Excluded:

Bottom Side Illuminated Region

- ☒ Group Reference: External radiation bottom
- Filter Type: Polygon Face
- ☒ Select Object (2)
- Excluded:

Orbit Selection

Orbit and Attitude Parameters: Beta 45 Orbi

Parameters

Calculation Method: Deterministic

Element Subdivision: 3

View

Card Name: Selected Elements Orbital Heating

OK Apply

Orbit Visualizer

File View Mode

Define and display the orbit.

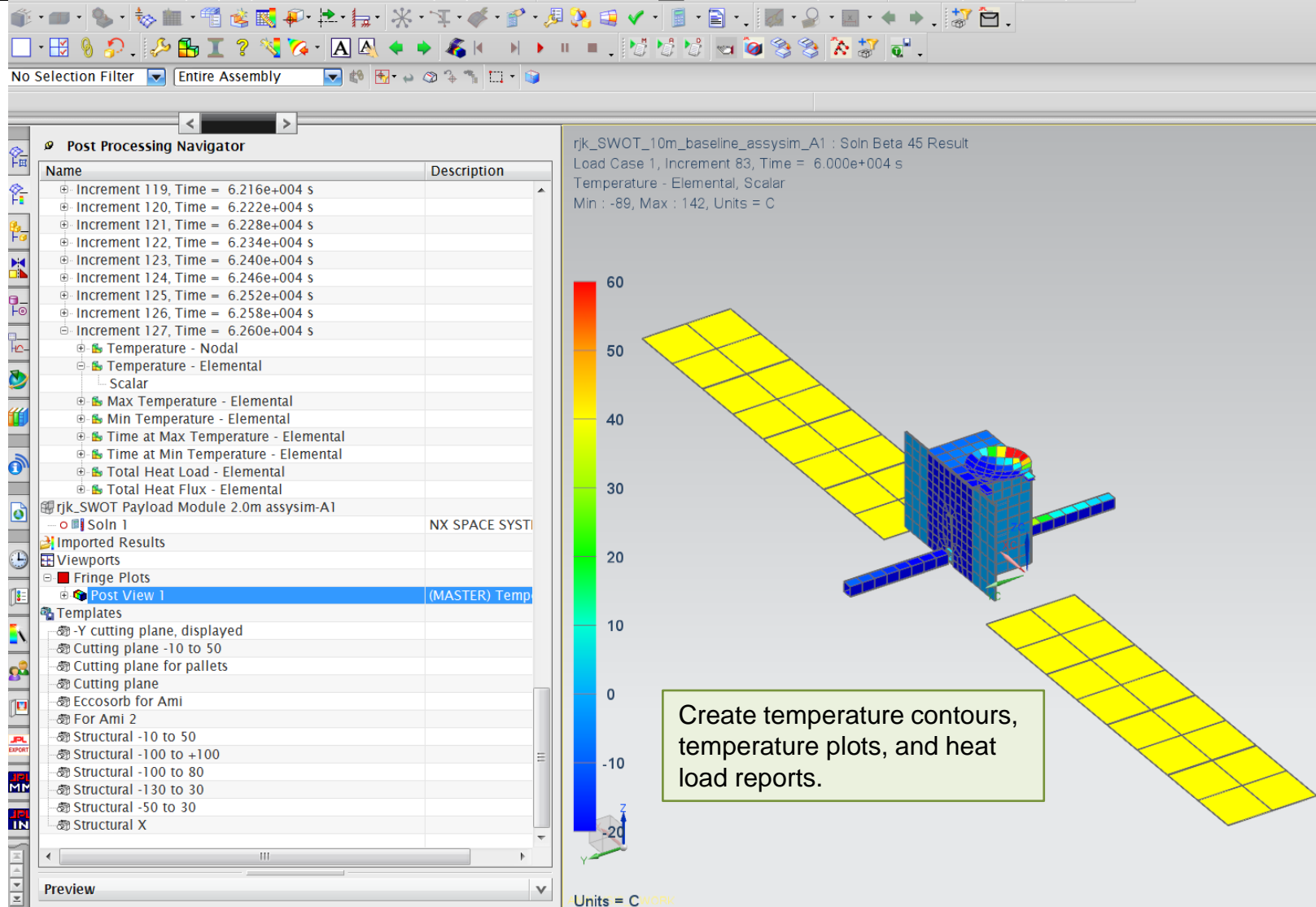
Time: 0.000000 [Ascending Node / Calculation Point #0] (Within Umbra)

Ambient Light

Animation



Solve and Examine Results





Summary



-
- You can work completely within Teamcenter to build and solve an orbital thermal model.
 - Your model will have a one-to-one correspondence to the parts and assemblies of the CAD model.
 - You can input thermal couplings and loads at the part and assembly levels.
 - Orbital thermal analysis is performed with Space Systems Thermal.



Where does this lead?



-
- NX parts are associated to the thermal model. An update to an NX part propagates automatically, with your permission, to the top level assembly FEM.
 - This will allow you to quickly assess the impact of design changes
 - The thermal analysis will be linked to the mechanical parts.
 - Assembly FEMs are modular.
 - You should be able to divide a spacecraft among several engineers for simultaneous analysis.
 - This leads to concurrent engineering.